Observations of Upper Ocean Hydrography and Currents in the Japan Sea

Stephen C. Riser
School of Oceanography, Box 357940
University of Washington
Seattle, Washington 98195
Phone: 206-543-1187 Fax: 206-329-0858 Email: riser@ocean.washington.edu

Award #: N00014-98-1-0182
http://flux.ocean.washington.edu

LONG-TERM GOAL

The long-term goal of this project is to better understand the properties of the upper portion of the water column in the Japan Sea. It is important to understand the seasonal cycle in the upper 800-1000 m of the Japan Sea: how the Sea stratifies in spring and summer and how it forms a mixed layer in fall and winter, sometimes with deep convection occurring, and the location and strength of the major features of the mid-depth circulation.

OBJECTIVES

It is desirable to study the circulation and hydrography of the upper 800-1000 m of the Japan Sea over at least a few complete seasonal cycles in order to understand the process of mixed-layer formation and destruction, and how the Sea responds to atmospheric forcing in the form of winter storms and cold air outbreaks. In some ways the Japan Sea behaves as a subtropical ocean, and in other ways it is more like a subarctic one; as a result, it is a useful laboratory for studying many oceanographic processes that occur throughout the world ocean. I have deployed 36 PALACE floats in the Japan Sea in this study, and the work discussed here fits into a larger program in the Japan Sea with about 20 PIs.

APPROACH

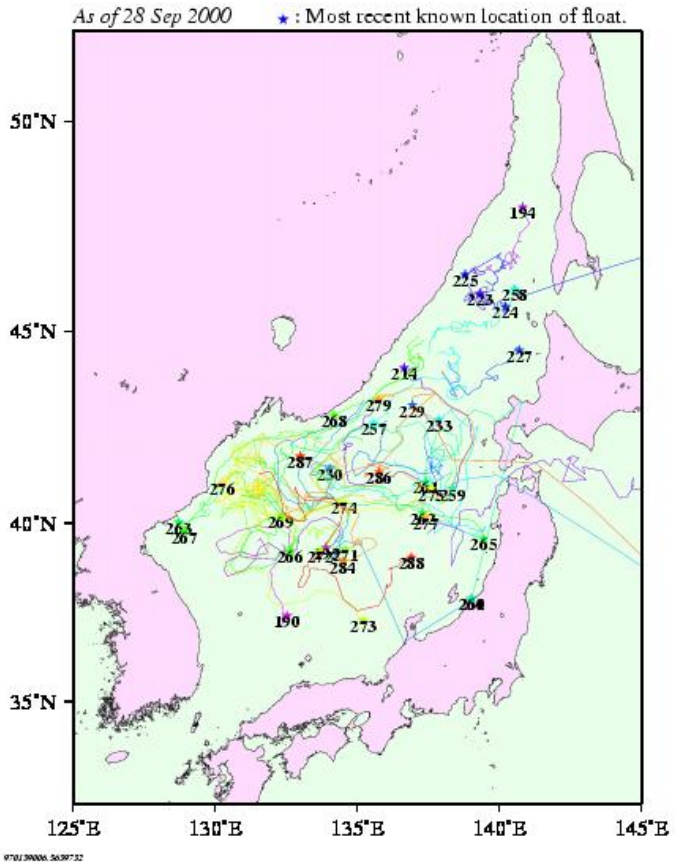
With the help of Russian collaborators, I deployed 36 PALACE floats in the western Japan Sea during the summer of 1999. These floats were deployed from the Russian research vessel *Professor Khromov*, from the FERHRI laboratory in Vladivostok. These floats are programmed to cycle between the sea surface and 800 m depth at approximately 7-day intervals and to collect profiles of temperature and salinity during their ascent phase on each cycle. In all, about 1500 profiles of temperature and salinity were collected in this way during the first year of this project. This has provided good coverage of the Japan Sea, even in the winter season. The floats should continue to return data for at least two more years. All of the results are being made available in real-time via the ARGOS system and a web page. I am presently doing similar work in the N. Atlantic, the Okhotsk Sea, and as part of ARGO, and all of these results can be viewed on the web at http://flux.ocean.washington.edu.

WORK COMPLETED

The components for the PALACE floats used in this work were purchased from Webb Research, Inc. We carried out the assembly at UW, as well as calibration, ballasting, and preparation for shipping. Most of the deployments were carried out inside the Russian EEZ in the Japan Sea in the summer of 1999. In order to carry out this work, clearance was requested from the Russian government approximately 2 years in advance of the deployments, and there was some doubt that it would be granted until just before the cruise departed. Most of the instruments were deployed by Russian scientists; no US personnel were allowed to participate in the cruise inside the Russian EEZ. Since the autumn of 1999 an analysis of the received profiles has been underway. At the present time the profiles are being examined for seasonal variations in mixed layer depth, temperature, and salinity, and the velocity vectors from the floats (both at the sea surface and at 800 m) are being analyzed.

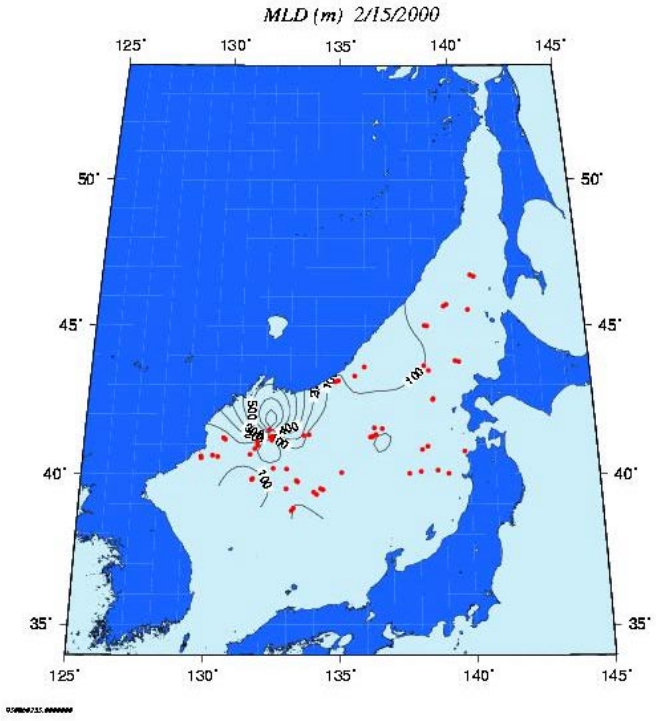
RESULTS

The fieldwork for this project began in August of 1999, and the data from the floats can be viewed in near real-time at the web site given above. This site is updated daily. The data received so far clearly show the seasonal cycle in the western Japan Sea, from the Russian coast in the vicinity of Tatar Strait in the north to the border region of North and South Korea in the south. By now, the floats have had over a year to disperse, and they cover a large region of the Japan Sea, as shown in the composite plot of all floats as of late September 2000 in the figure below.



As the figure shows, several of the floats have already escaped from the Japan Sea into the North Pacific through Tsugaru Strait, between the Japanese islands of Honshu and Hokkaido, and one of the floats has escaped into the Okhotsk Sea through Soya Strait.

Perhaps the most striking result found so far is the observation of a region of apparent deep convection in the western Japan Sea during January and February 2000. The floats clearly showed a small region, estimated to be about 25 km in diameter, where the wintertime mixed layer was at least 850 m deep (the parking depth of the floats). The potential density in this mixed layer was less than 0.03 σ_θ units less than the climatological mean potential density at the *bottom* of the Japan Sea, suggesting that the convection could have extended to the bottom. This is the first known observation of *in situ* deep convection in the Japan Sea. A map of the mixed layer depth for the Japan Sea during mid-February of 2000 is given in the figure below. Note that for most of the Japan Sea, there is no mixed layer, or only a very shallow one, in winter. It is only in the region off Vladivostok where the mixed layer deepens.



IMPACT/APPLICATION

This work has had several impacts and applications. From a scientific perspective, the profiles near Vladivostok in during the winter of 1999-2000 represent the some of the first high quality water column data from this region of the ocean. The data clearly show the presence of wintertime convection and deep winter mixed layers. Other floats, farther north along the Russian coast, reveal the presence of cold, fresh boundary currents in winter and spring, probably related to melting ice. These are important features of the circulation that have not been previously seen, and they should have a large impact on assessing the quality of numerical models of the Japan Sea. At the present time, I am working with Drs. Patrick Hogan and Harley Hurlburt at NRL/Stennis to examine these data in the context of their models of the Japan Sea. A different type of application involved the winter 2000 cruise of the *Professor Khromov* in the region near Vladivostok, funded by ONR and carried out by Russian scientists. The PALACE profiles from the region showed the convective region near Vladivostok, and the data were used to direct the ship to the exact region of convection, with the idea that detailed CTD and chemical sampling could be carried out in the convective zone. Unfortunately,

the convection ceased (after continuing for over one month) on the day before the ship arrived in the region, so the details of convection were not sampled.

TRANSITIONS

In the past year we have worked closely with the Naval Oceanographic Office (NAVO) in order to help them begin a PALACE float program at their laboratory. The help that we have given NAVO has to a large extent been based on the experience that has been gained by carrying out this project in the Japan Sea. We have attempted to transition our experience to NAVO in three different ways: (1) we have helped the NAVO group gain experience with using PALACE floats; (2) we have helped them to set up a web page to view their data, and have provided web service at the University of Washington for their project; their web page can now be reached at http://flux.ocean.washington.edu/navo; and (3) we have helped them learn to air-deploy PALACE floats by providing several of our floats (not purchased using ONR funds) as test floats for air-deployment from C-130 aircraft. As a result of the use of our floats, the NAVO floats now certified for air-deployment from C-130s. NAVO has used this technique to deploy PALACE floats in the South China Sea, the Arabian Sea, the Red Sea, and the Mediterranean Sea. It is planned that NAVO will deploy air-deploy a few floats in the Japan Sea before the end of 2000.

RELATED PROJECTS

A number of other investigators are also working on the Japan Sea project. I have worked most closely with Prof. Lynne Talley of Scripps, who was chief scientist on the *Revelle* hydrography/tracer cruise in the Japan Sea during the summer of 1999. Prof. Talley and I also worked together in planning and the *Professor Khromov* cruises in the summer of 1999 and winter of 2000. The ship time for these cruises was funded through the Japan/East Sea Project Office at the University of Washington, which is also funded by ONR. I have also been involved in additional PALACE float work; several floats have been deployed in the Okhotsk Sea (with funding provided by Hokkaido University), approximately 70 floats have been operative in the N. Atlantic as part of the WOCE/ACCE program since 1997 (funding provided by NSF), and recently I have been beginning float deployments as part of ARGO (funded through NOPP) in cooperation with several other US principal investigators.